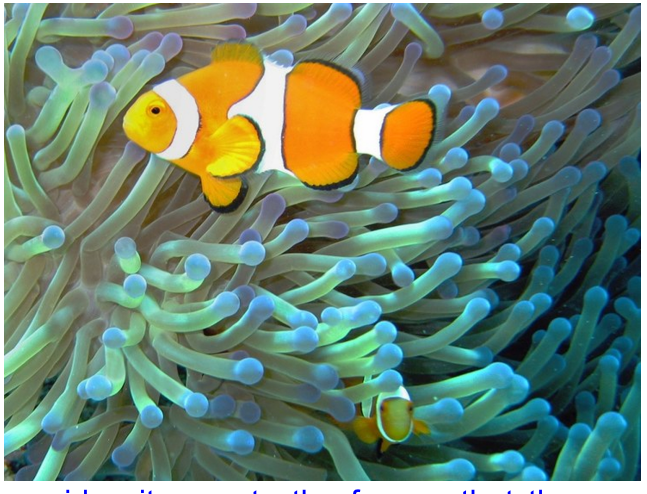


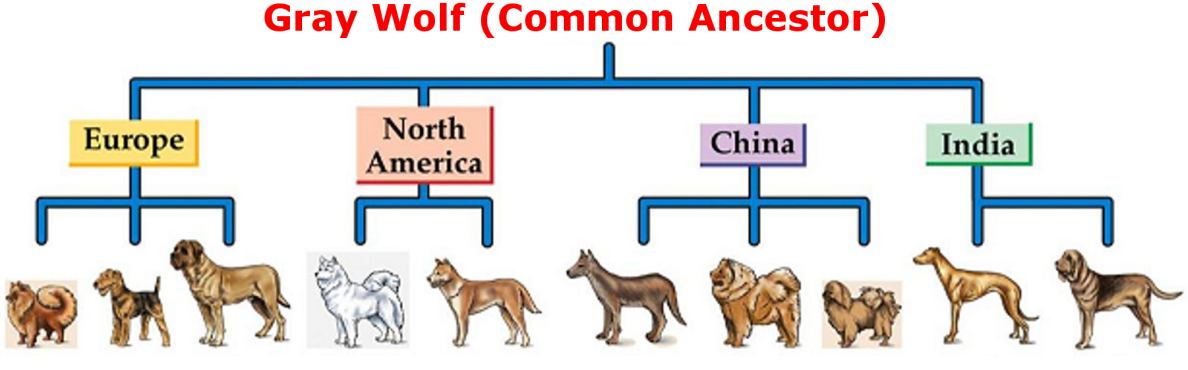
Darwinian evolution is always the result of competition between living organisms for resources which are in limited supply. But examples of cooperation between individuals of the same or even different species is very common. The sea anemone and the clown fish are a good example of cooperation or symbiosis as it is called. {Picture left} The tentacles of the sea anemone offer good protection to the clown fish, The clown fish also eats the scraps of food left by the anemone. It also eats the small beings that attack the anemone. The faeces of the fish provide nitrogen to the fungus that the anemone needs. The whistling of the clown fish frightens some of the fish that would otherwise attack the anemone.

Ants, bees and termites are social insects. Millions of these organize themselves into large colonies where individuals show wonderful cooperation. They are very often shown as examples from which humans should learn. But detailed study has shown that this cooperation is the result of the differences in genes. The genes of the worker bee are different from those of the queen bee.

The most interesting examples of genetic change due to mutual cooperation is found in humans. In all mammals, babies need mother's milk for survival and humans are also mammals. But, in all cases the adult animals cannot digest milk. This is very necessary in

nature. If the older babies can digest milk, they will fight with the younger, weaker siblings for milk. Surprisingly, some human adults can digest milk; but only those belonging to pastoral societies who had domestic animals that provided milk. Because milk as food was easily available, the adults who could digest milk had more progeny. The disadvantage of adult children competing for mother's milk was much less than the advantage of the adults using milk as a food. In those human societies which did not have milk from domesticated animals, adults cannot digest milk even today.

Humans changed their own genes by domesticating milk providers. They took another important step in altering nature, twenty five thousand years ago, by converting the grey wolf into domesticated dogs. {Picture below} Genes of any of the domestic dogs on the earth differ very little from the genes of the grey wolf. Remains of domestic dogs, many of them twenty thousand years old, have been identified on all continents. Dog breeds do not differ in their genes. But a fully grown Chihuahua weighs at most 2 kg while a fully grown

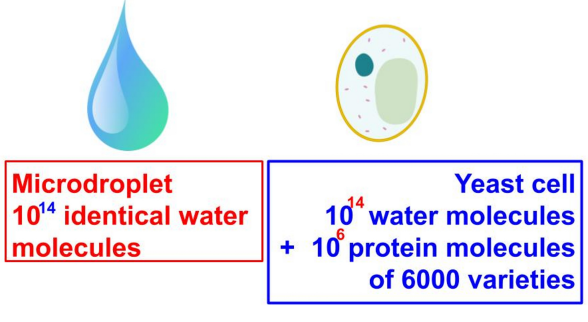


English Mastiff could easily weigh 70kg. Though differences in genes are very small, dogs differ quite a lot in their appearance. A tiger and a leopard in contrast are genetically more different but their appearances are very similar. Genes apparently do not even determine the appearance. Differences between humans are rarely due to genes.

Humans domesticated animals like cows, sheep, goats, horses and selected those that gave maximum benefit. So there are large differences between the domesticated animals and the natural ancestors. For example, in nature, a cow would give as much milk as the calf needs. Not more. A cow that gives more milk will have fewer calves. So it loses the competition for natural resources with other cows. But cows which give more milk are preferred by humans. Food crops offer other examples of human modification of nature. Scientists found that wheat agriculture started around 12,000 years ago. Wild grasses similar to wheat are still found in nature. But their seeds are loosely attached to the spine. So wind takes them much farther from the plant. This helps the growth of newer plants. But collecting such seeds for eating is very difficult. So the ancient humans selected wheat plants whose seeds are strongly attached to the spine for cultivation. Similarly, they had selected, again and again, plants which gave very large seeds. Similarly the original maize plant had a kernel with a few seeds. {Picture right} This had become a plant with a kernel having four hundred seeds, even before the modern scientific methods were available, Humans had also selected plants for their beauty and attractive smells. Most

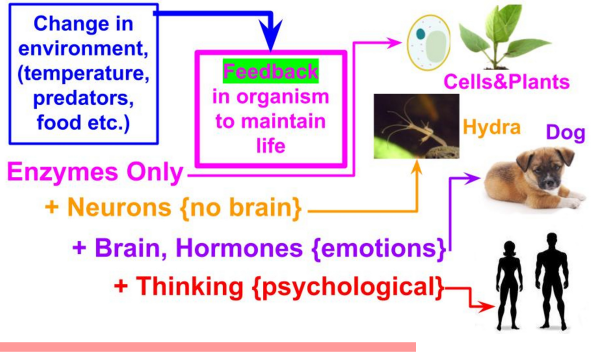
of these varieties of plants and animals can not survive independent of humans. Humans need them. But they too need humans for survival.

All trees do not grow to the same height. All fruits on a tree are not identical. Brothers differ from one another. Even identical twins who have exactly the same genes do not get the same disease at the same time. Because every individual living being is different from others, biology uses statistics to study them. Physics and chemistry use mathematics. Biomolecules obey the laws of chemistry. Living cells cannot violate laws of chemistry and physics. But all properties of living beings cannot be completely described using physics and chemistry. Let us compare a single cell of yeast used for making bread and a droplet of water with the same volume. {Picture below} There are about a hundred trillion, 10^{14} molecules of water in the droplet and they are all identical to one another. Even if some salt is dissolved in the water, the salt molecules are all identical and have the same chemical properties. That is the reason properties of water are described by the mathematical laws of physics and chemistry. The single cell of yeast will also have the same number of water molecules. But in addition there will be about one hundred thousand biomolecules. There are some six thousand different molecules too. When one yeast cell is compared with another, there will always be differences in the numbers of all these different biomolecules. Darwinian evolution shows that there could also be small changes in the atoms and bonds that are in the biomolecules. Because of these differences, the properties of two different living beings are never identical.



When a pest attacks a field of rice, {Picture below left} not all the plants in the field are affected. If a pesticide is sprayed by the farmer to kill the pest, some plants are cured, but some other plants may die due to the pesticide. To know how much pesticide has to be used, scientists will divide a field into smaller parts. Pesticide is applied only to some parts and the differences are observed. To compare a part to which pesticide has been applied with one that has not been, one should have the confidence that the two parts are identical and that both would continue to be similar if no pesticide had been used.

To divide a population of living beings into practically identical groups is not easy. As one moves from simple single celled organisms like the amoeba to humans, the complexity of the organism increases. So the difficulty of dividing the population into nearly identical groups also becomes more difficult. As mentioned earlier, living beings have a large number of positive and negative feedback loops which enable them to maintain their internal order when the surroundings change. As the complexity of living beings increases, the nature of these feedbacks also changes. {Picture below right} In single celled living organisms, the feedbacks are chemical reactions due to enzymes. When the living being



consists of a large number of cells, chemicals act as messengers from one cell to another. In even more complex organisms like a hydra, there are nerves which send signals from one cell to another. But in these, the nerve system is extremely primitive. There is no brain. In more complex animals with a brain, hormones change the feelings. The well developed nervous system participates in the feedback. {Picture bottom right previous page} In the case of humans, thoughts, rational arguments and discussions with other people will all be relevant for a feedback response. This is the reason dividing humans into groups and comparing them more often leads to disputes rather than scientific conclusions.

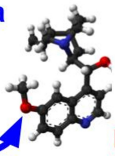
Living beings can be understood by experimenting with biomolecules using the methods of physics and chemistry. The alternative method is to identify identical groups and study the differences between them. Areas like medicine and social sciences try to provide scientific results more useful for human life than fundamental biology. These are totally dependent on comparison of identical groups.

Human understanding of physics, chemistry and biology has undergone a revolutionary change following the work of Newton, Dalton and Darwin. The foundation stone of this change is the acceptance of the experimental method. Similarly, accepting the necessity for comparison of groups is a revolutionary change in human understanding of medicine.

Only a few people support ideas like creation of free energy or flat earth which are totally rejected by modern science. But quite a large number of people support the so-called alternative medicine and criticise modern evidence based medicine. Some claim that verification using modern methods is not necessary for these systems. Some others complain that pharma companies, in search of profits, are suppressing these systems.

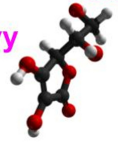
Many argue that personal experience has to be valued even when not verified by comparing identical groups.

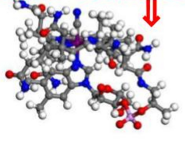
⇐ Cinchona bark as medicine for Malaria Quinine



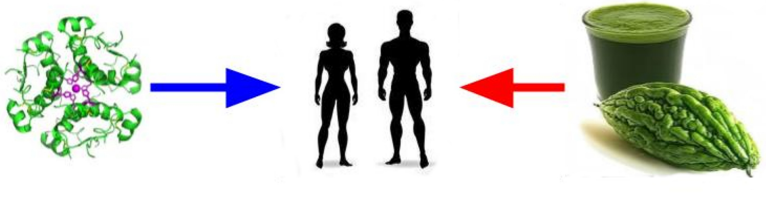
⇑ Eating raw liver cures Pernicious Anemia Cobalamin Vitamin B12 ⇓

⇐ Lime juice prevents scurvy Ascorbic Acid (Vitamin C) ⇒





Some medicines which are accepted by modern evidence based medical system were discovered before the comparison of groups or double blind testing as it is called was known. The science of why they work was also not well understood. {Picture right} For example, even before the discovery of vitamin C, ascorbic acid and its importance for human health, it was known that a daily dose of lemon juice prevents scurvy. First it was realized that eating raw liver prevented deaths due to pernicious anaemia. Vitamin B12, present in raw liver was later identified as the actual medicine. First, the bark of cinchona was identified as a cure for malaria. Quinine was isolated later. There are many other such examples. Two points are very important. If the medicine was really effective, testing and identification of the real science will not take much time. More importantly. the proposed medicine will have to agree with the other biochemical processes known to science. For example, the juice of bitter gourd is proposed as a novel cure for diabetes. {Picture left} If there is an active chemical in the juice, it should cause changes in insulin



levels. Without insulin how does glucose give energy to every cell? Like other modern medicines, the effect should be visible in cell cultures. Like all other foods we eat, bitter gourd juice would get digested. Inside the intestine, only small molecules like amino acids and glucose can enter the blood. Such basic questions of biology need to be answered. If there are no answers, one has to concede that the proposed cure is unscientific. The ultra modern craze for organic food and advertisements for cosmetics are among many other areas where the same criticism is valid. How can the calcium in the tooth paste cross the tooth enamel? Why is not the skin a barrier to molecules in the oil when it is a barrier to the molecules in polluted atmosphere. Only very few molecules can cross even the thin skin inside of the nose, the tongue or the mouth. Smell and taste are the result of specific molecules touching the receptors in the nose and tongue. The molecules do not enter the human body.

Some understanding of statistics is required to understand why scientists rely only on group comparisons and question individual experience. Even when comparing groups and the standard scientific method is used, the conclusions from two experiments could contradict each other. This is particularly common in social sciences. So understanding the strength of the scientific conclusion is very important. Before taking up this discussion we will take a look at how life and humans have altered the earth and its environment.